US011781922B2

(12) **United States Patent**
Nemet

(10) **Patent No.: US 11,781,922 B2**
(45) **Date of Patent: Oct. 10, 2023**

(54) **THERMOCHROMIC INK INDICIA FOR ACTIVATABLE QUALITY LABELS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 22 days.

(21) Appl. No.: **17/359,914**

(22) Filed: **Jun. 28, 2021**

(65) **Prior Publication Data**

US 2021/0389190 A1 Dec. 16, 2021

Related U.S. Application Data

(63) Continuation of application No. 15/574,353, filed as application No. PCT/IL2016/050526 on May 18, 2016, now Pat. No. 11,060,924.
(Continued)

(51) **Int. Cl.**
G01K 11/12 (2021.01)
G09F 3/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G01K 11/12*** (2013.01); ***G01K 3/04*** (2013.01); ***G09F 3/0294*** (2013.01); *G06K 19/0614* (2013.01); *G09F 2003/0211* (2013.01)

(58) **Field of Classification Search**
CPC G01K 11/12; G01K 3/04; G09F 3/0294; G09F 2003/0211; G06K 19/0614
See application file for complete search history.

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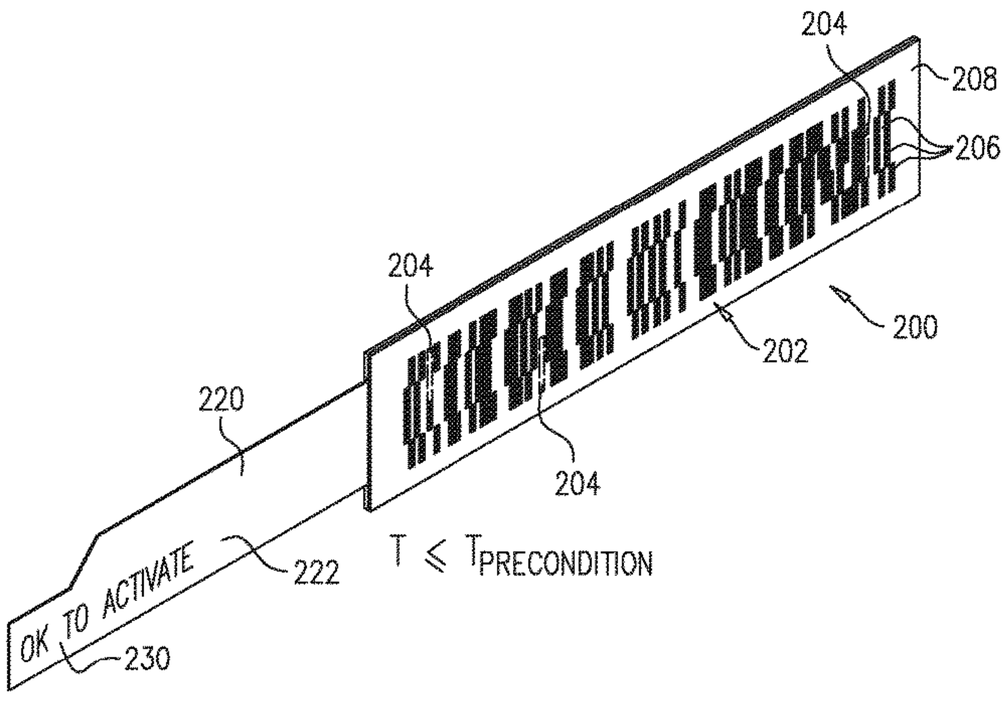
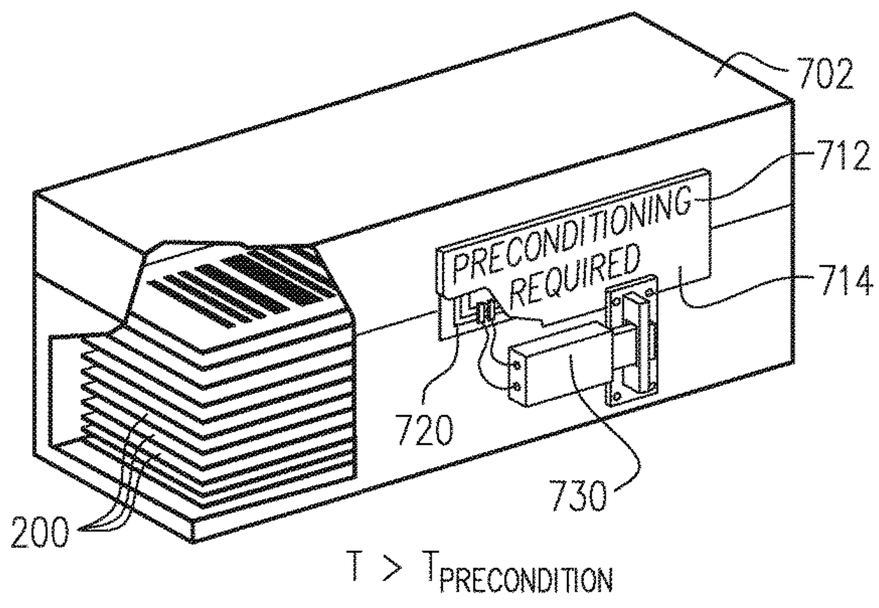
(57) **ABSTRACT**

An activatable quality label operative to provide an indication of exceedance of a temperature threshold following activation thereof at a temperature less than or equal to an activation temperature, including a readable indicator located on the quality label and operative, following activation of the quality label at or below the activation temperature, to readably indicate exceedance of the temperature threshold, an actuator element operative to activate the quality label and indicia at least partially formed by thermochromic ink, the thermochromic ink having a first visual appearance at temperatures less than or equal to the activation temperature and a second visual appearance at temperatures above the activation temperature, such that a visual appearance of the indicia is indicative of whether the quality label is at a temperature less than or equal to the activation temperature and hence may be activated.

14 Claims, 7 Drawing Sheets





Related U.S. Application Data

(60) Provisional application No. 62/163,193, filed on May 18, 2015.

(51) **Int. Cl.**

G01K 3/04	(2006.01)
G06K 19/06	(2006.01)
G09F 3/02	(2006.01)

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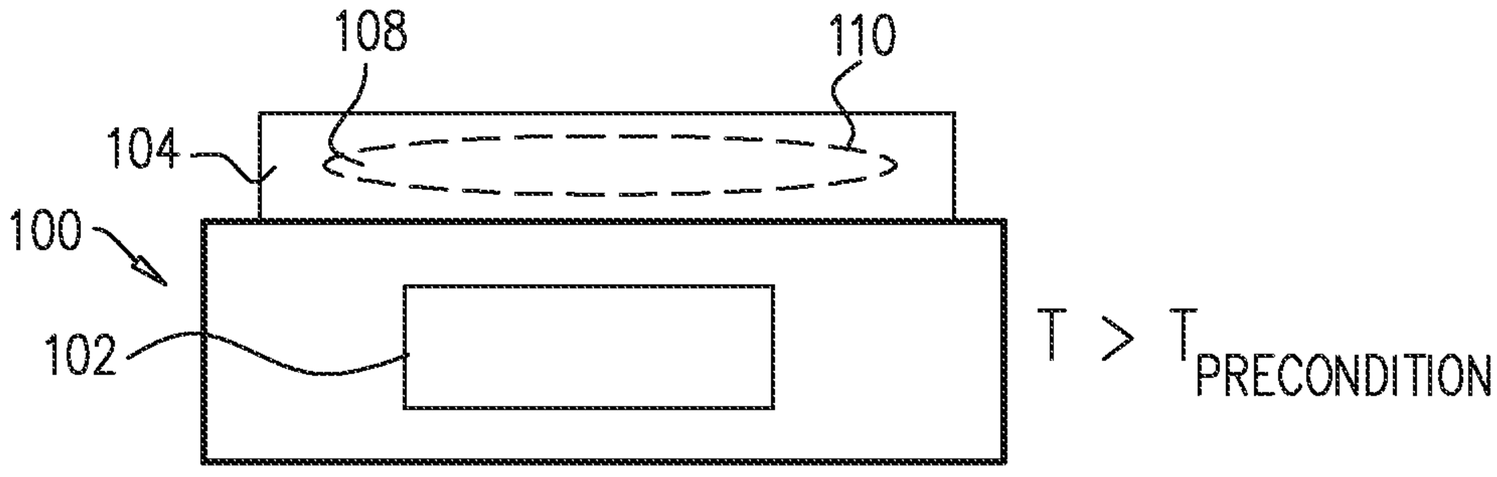
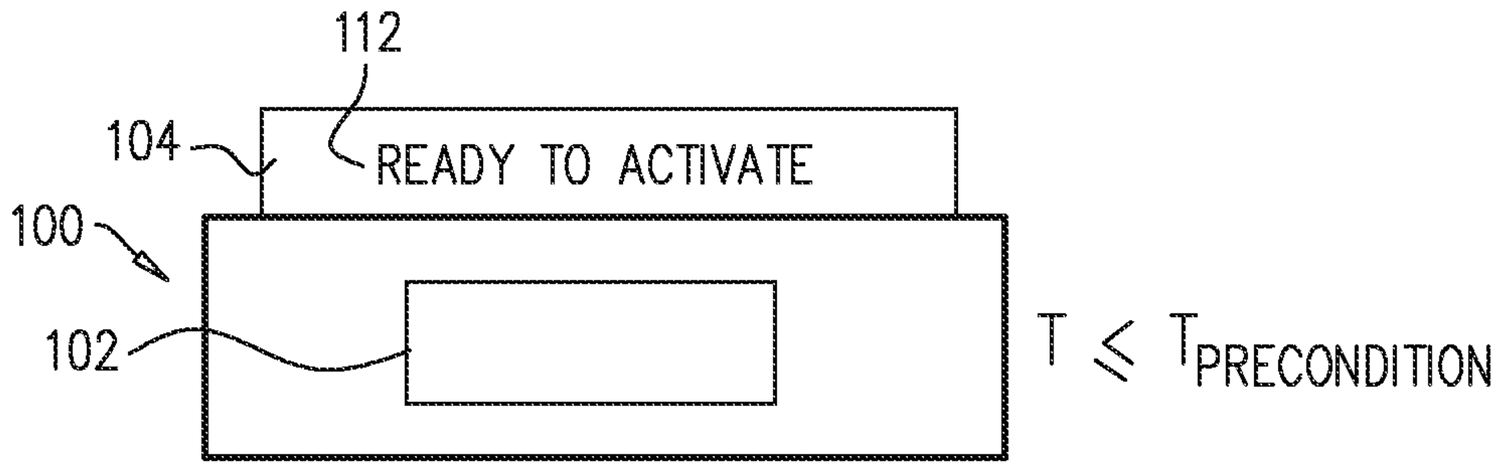


FIG. 1A



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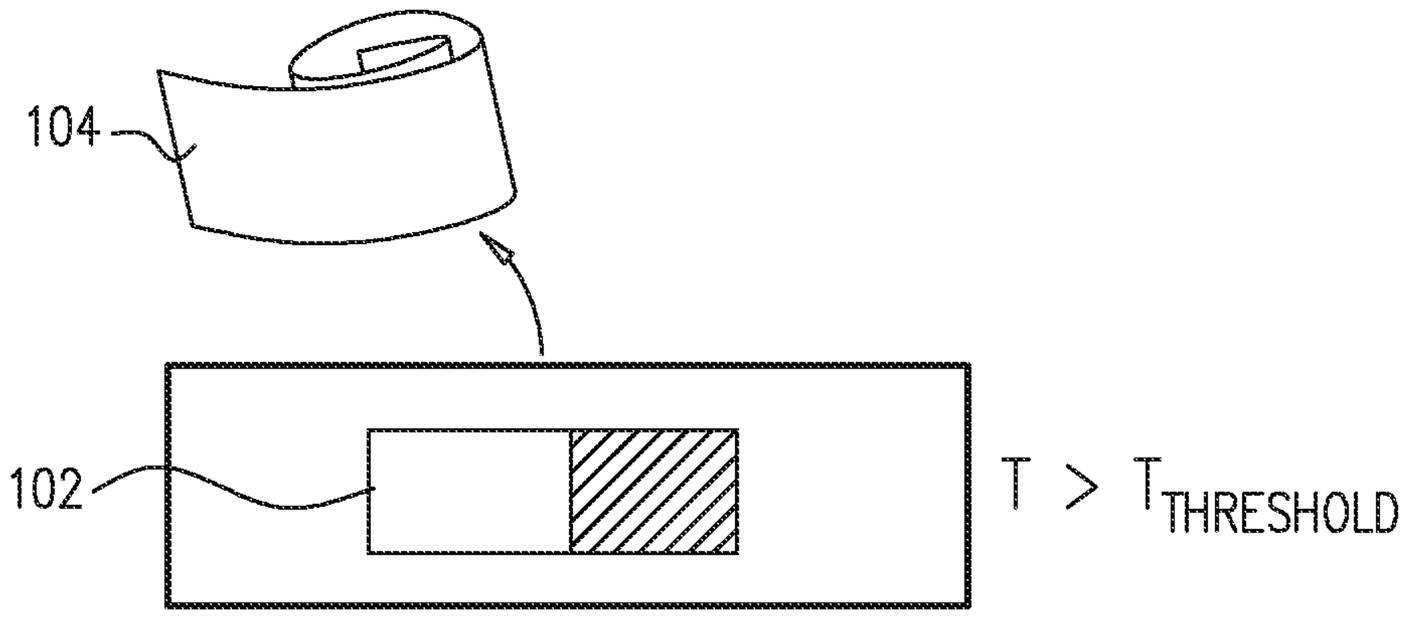

FIG. 1C

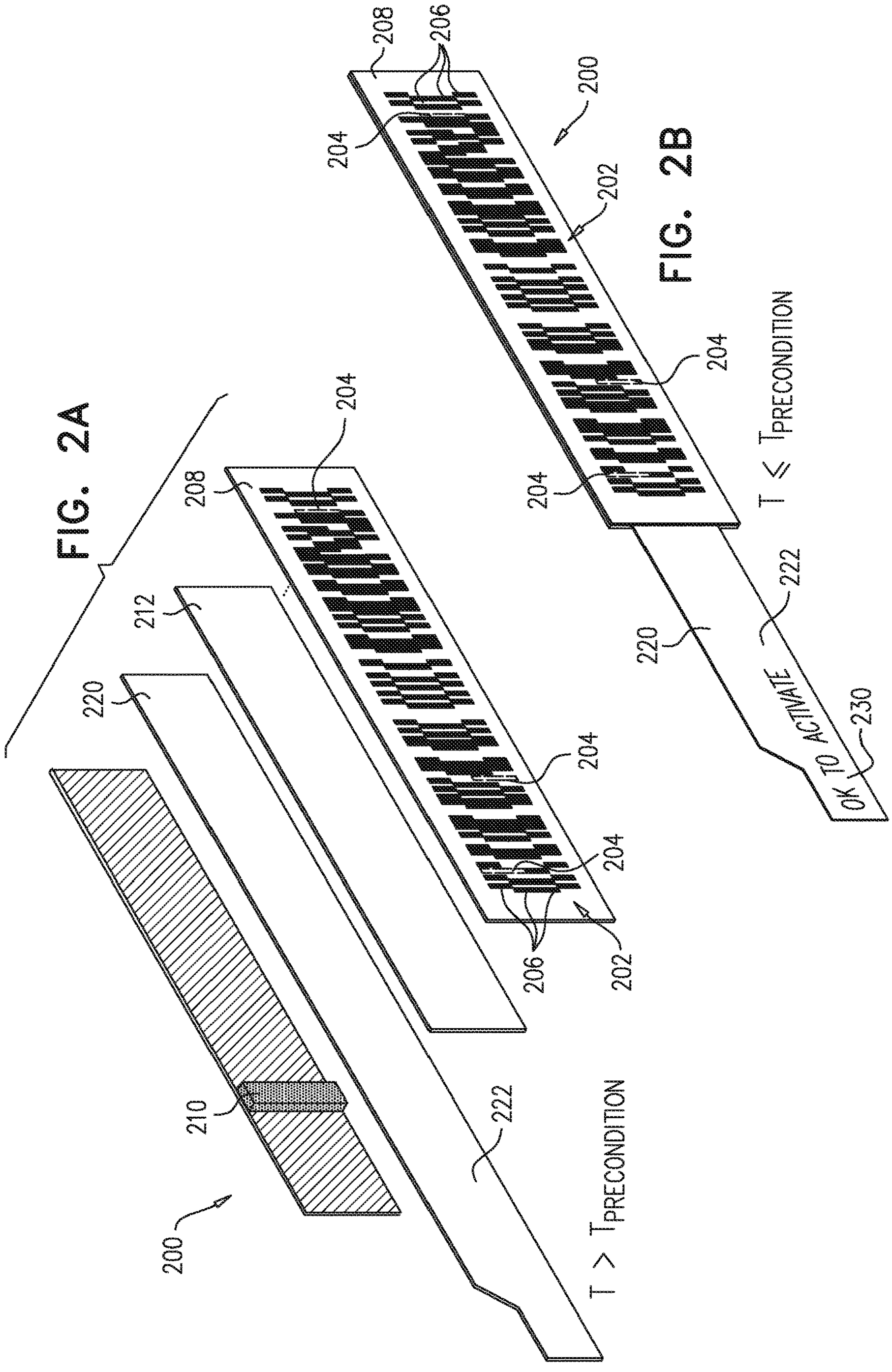
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FIG. 2A

FIG. 2B

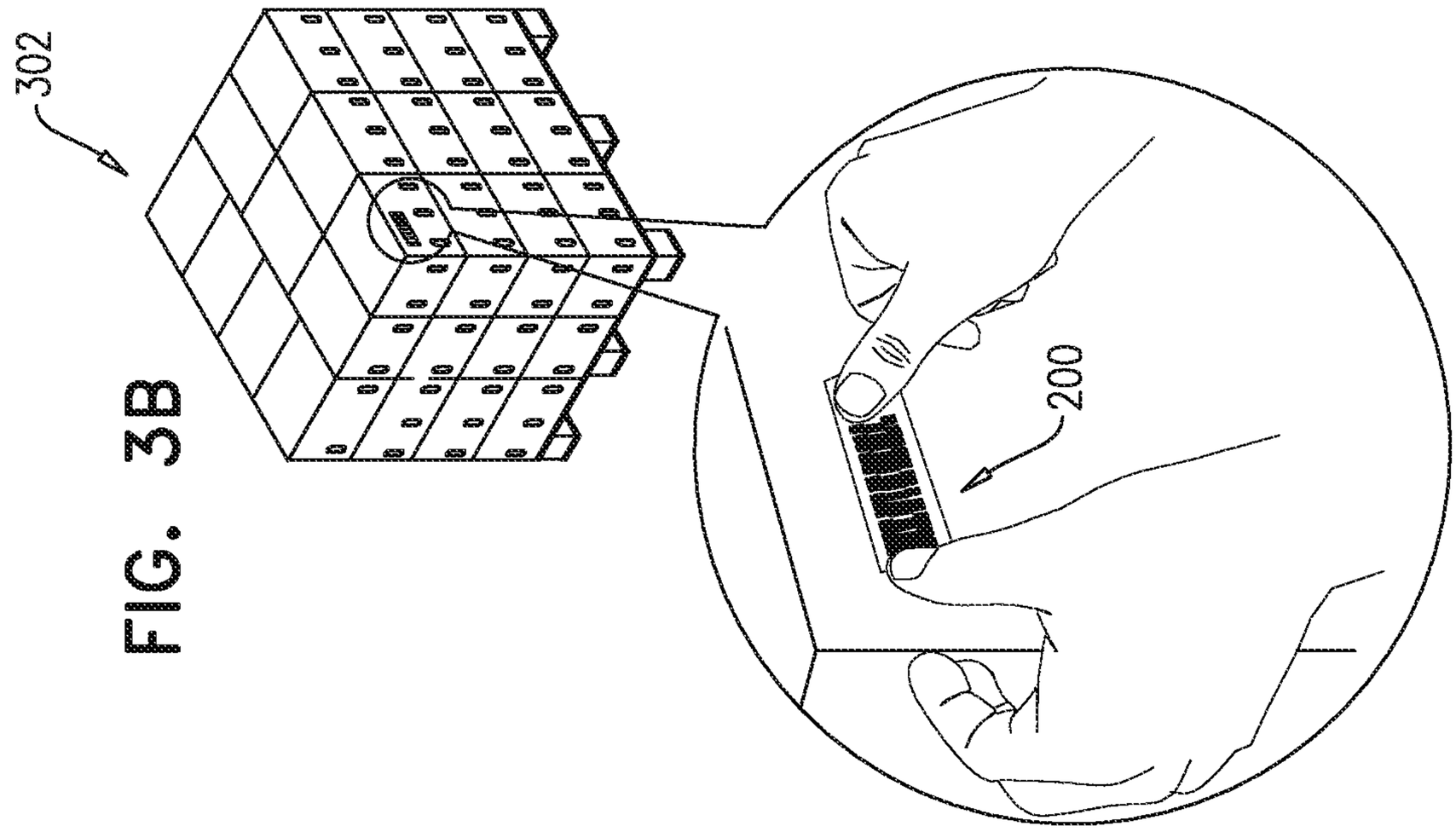
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FIG. 3B

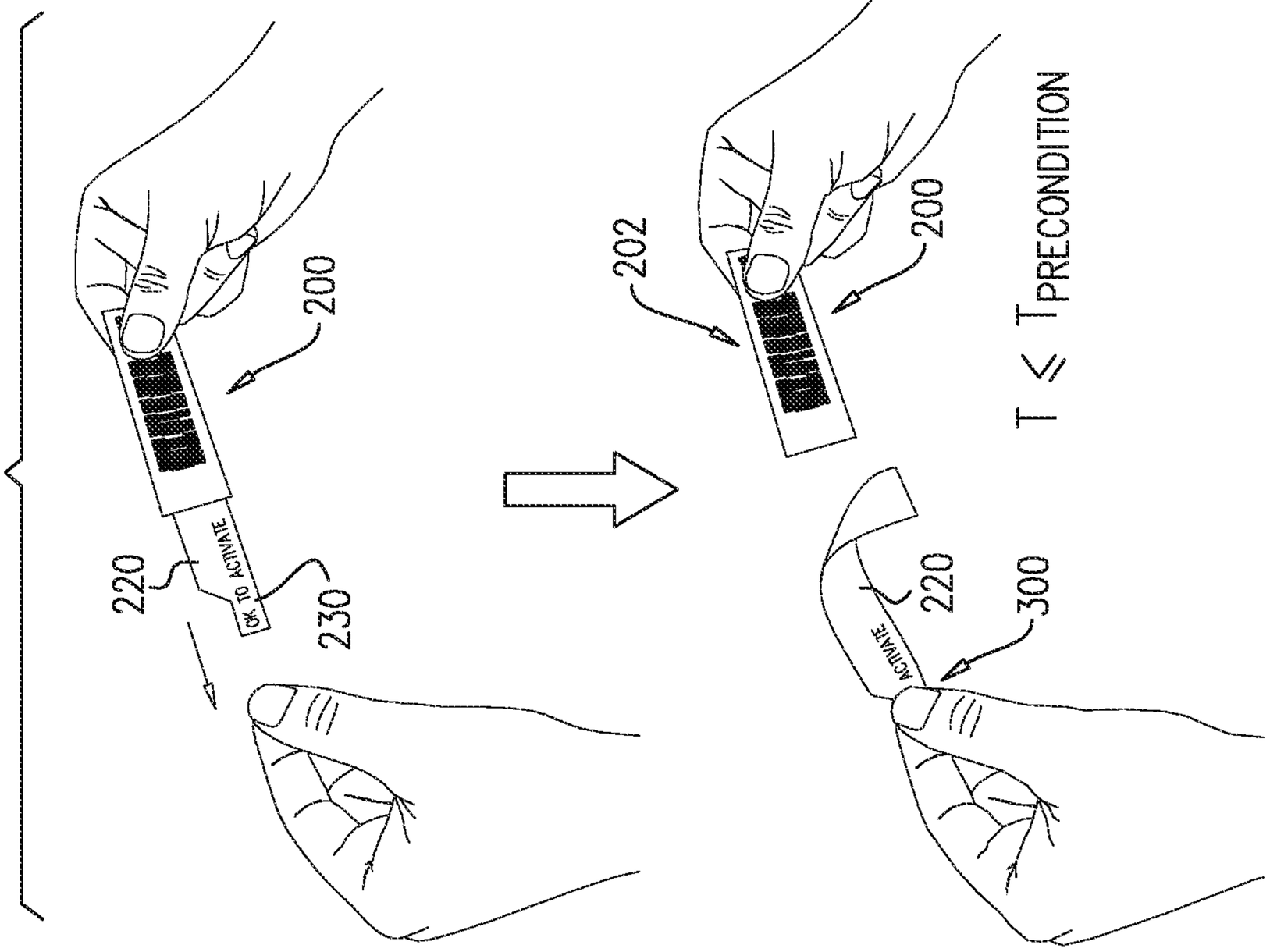
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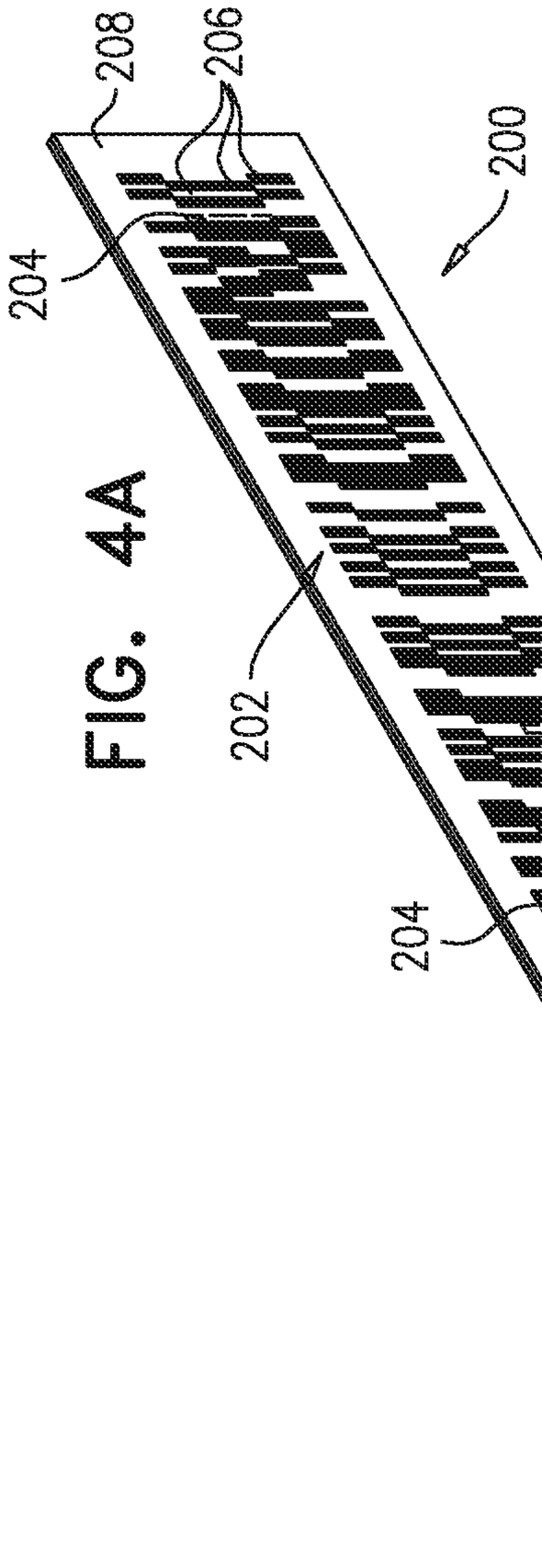
FIG. 3A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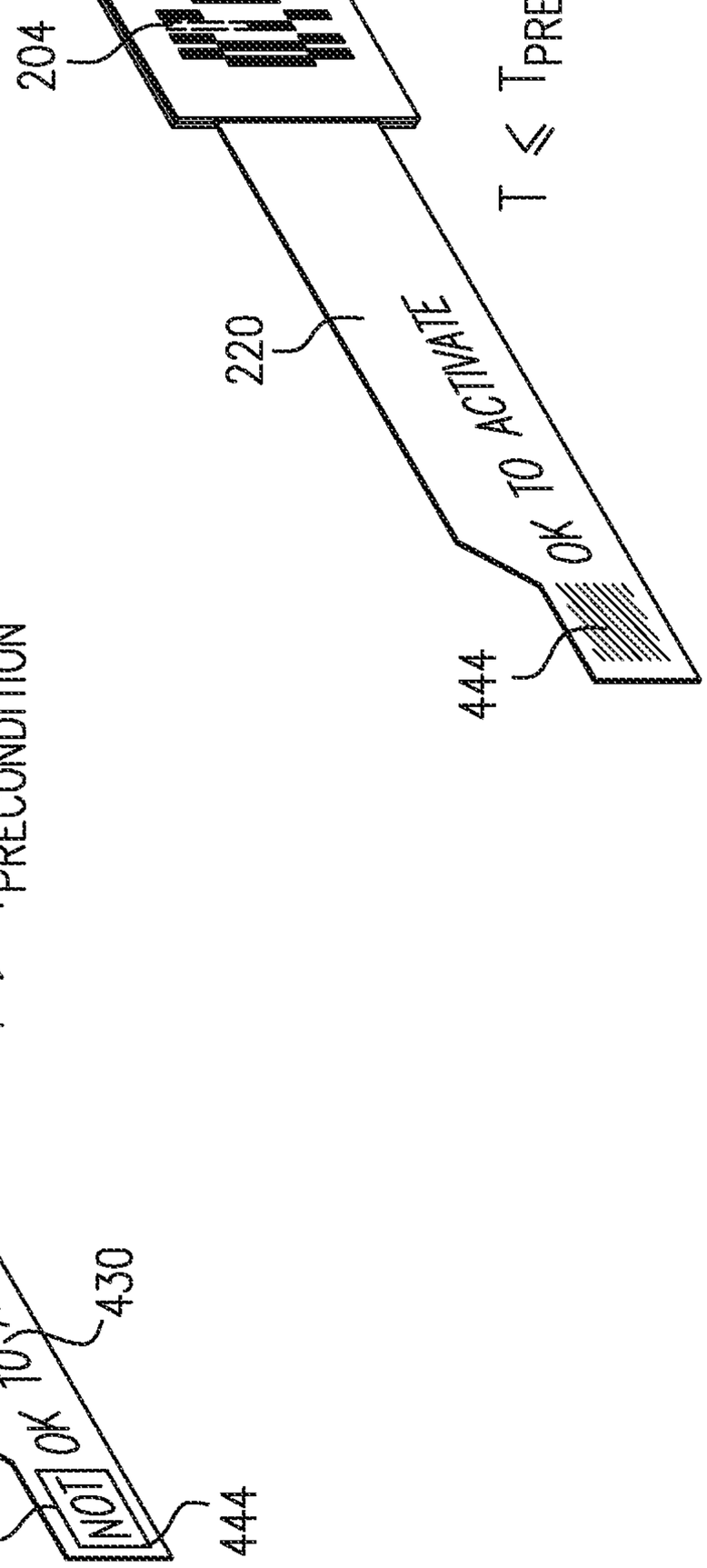
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FIG. 4B

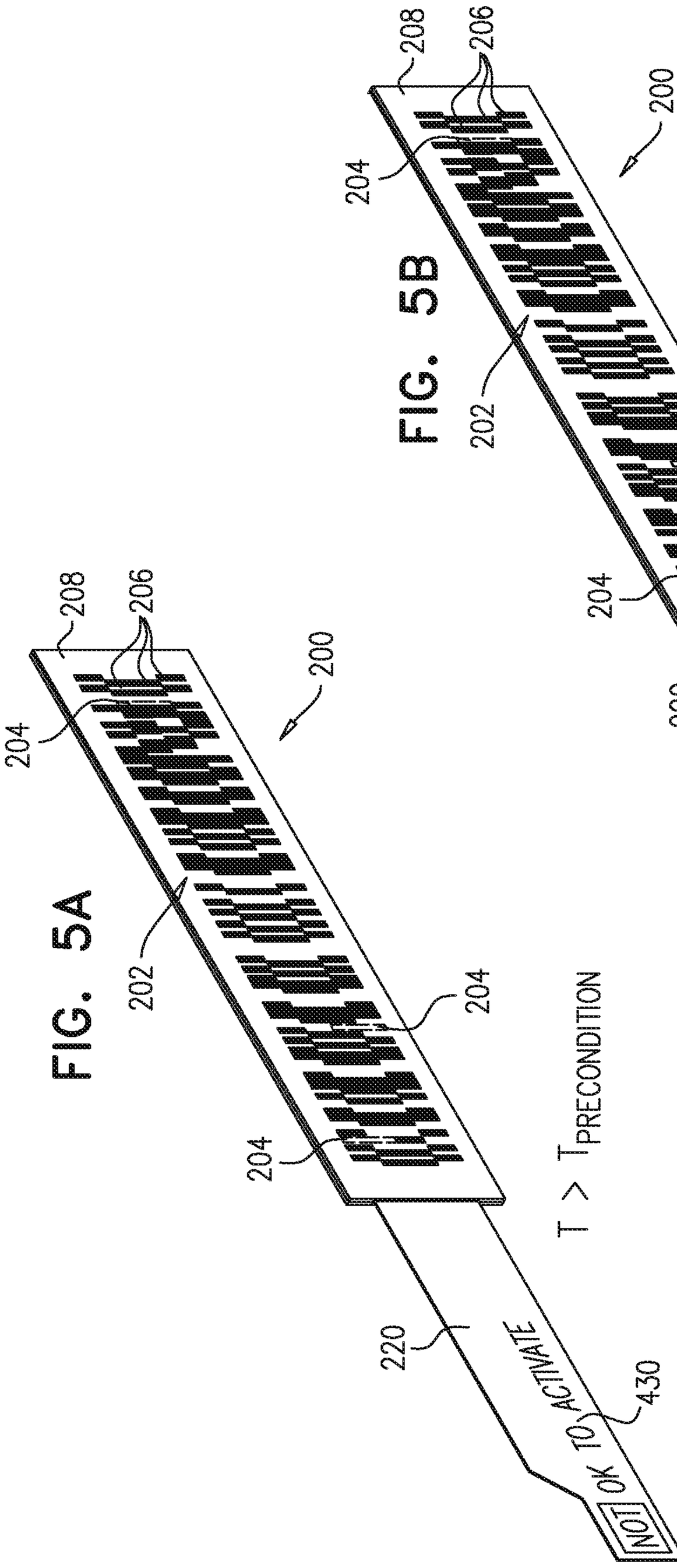
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FIG. 5A

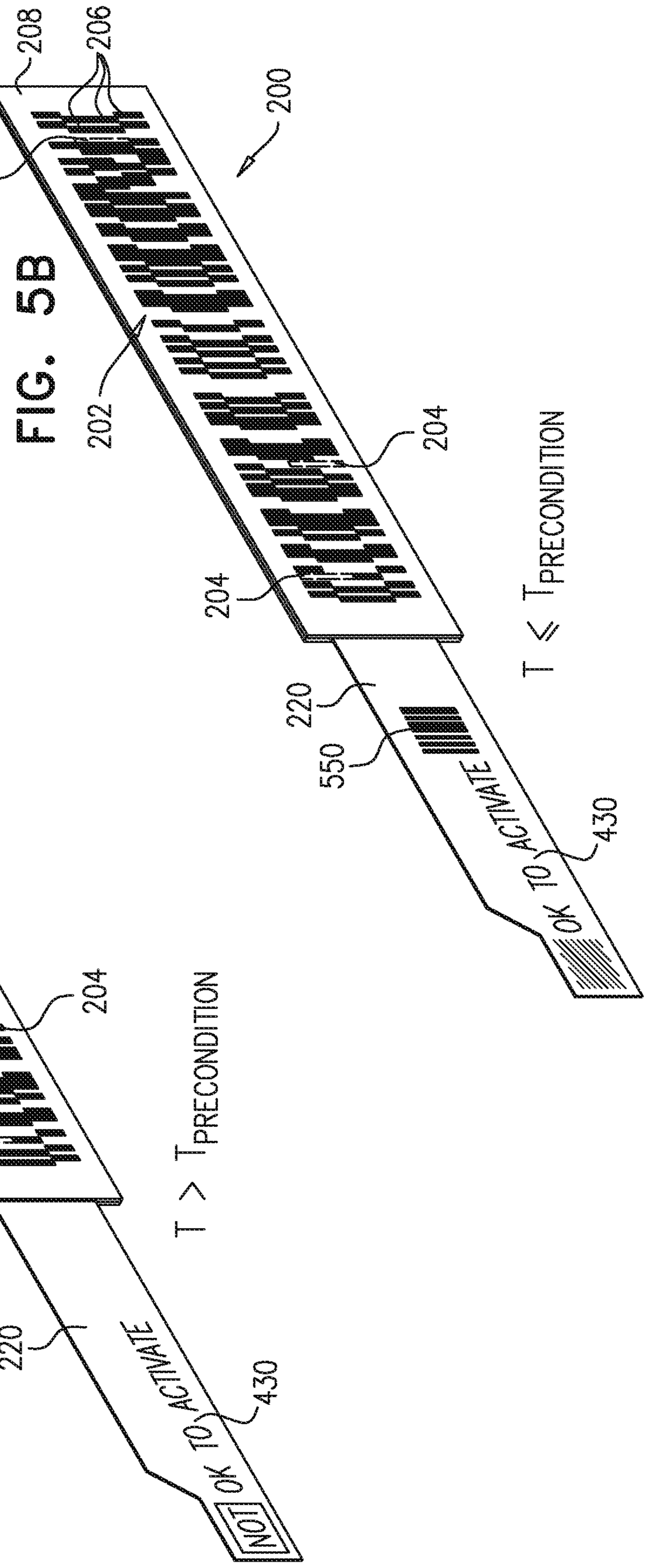
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FIG. 5B

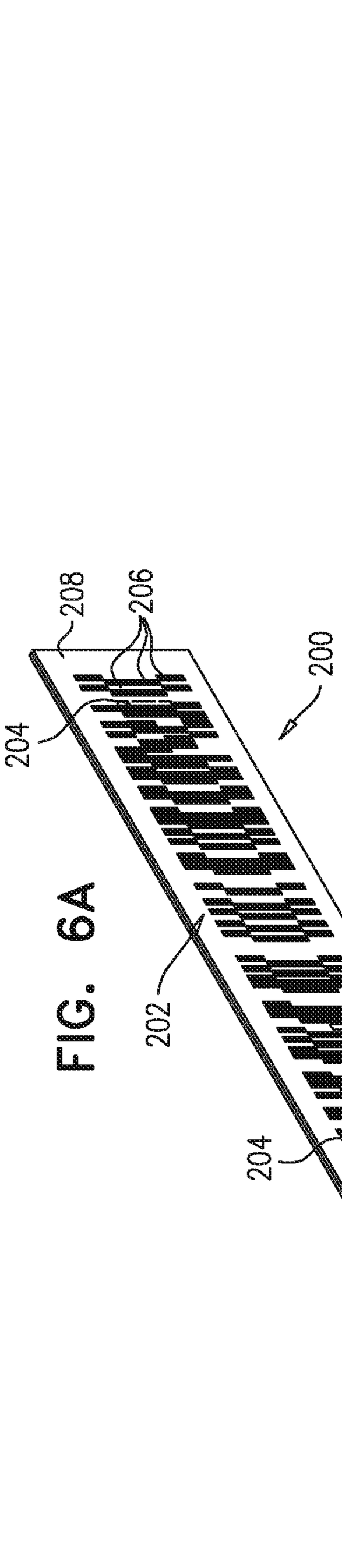
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FIG. 6A

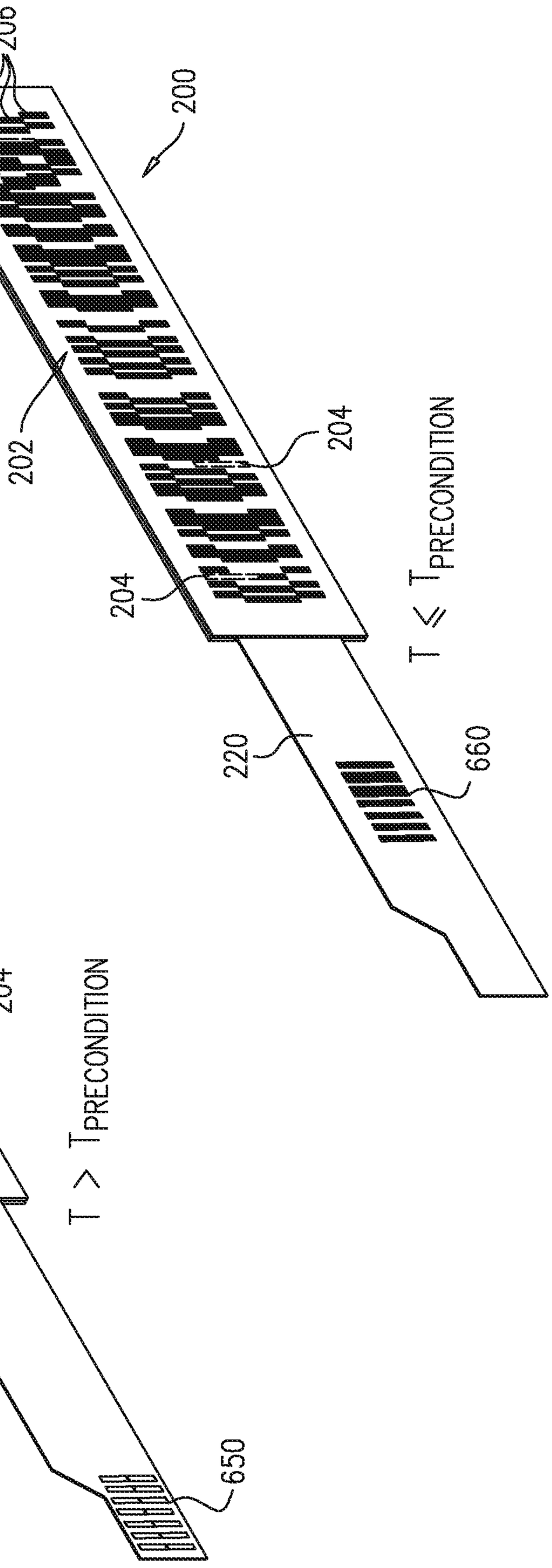
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FIG. 6B

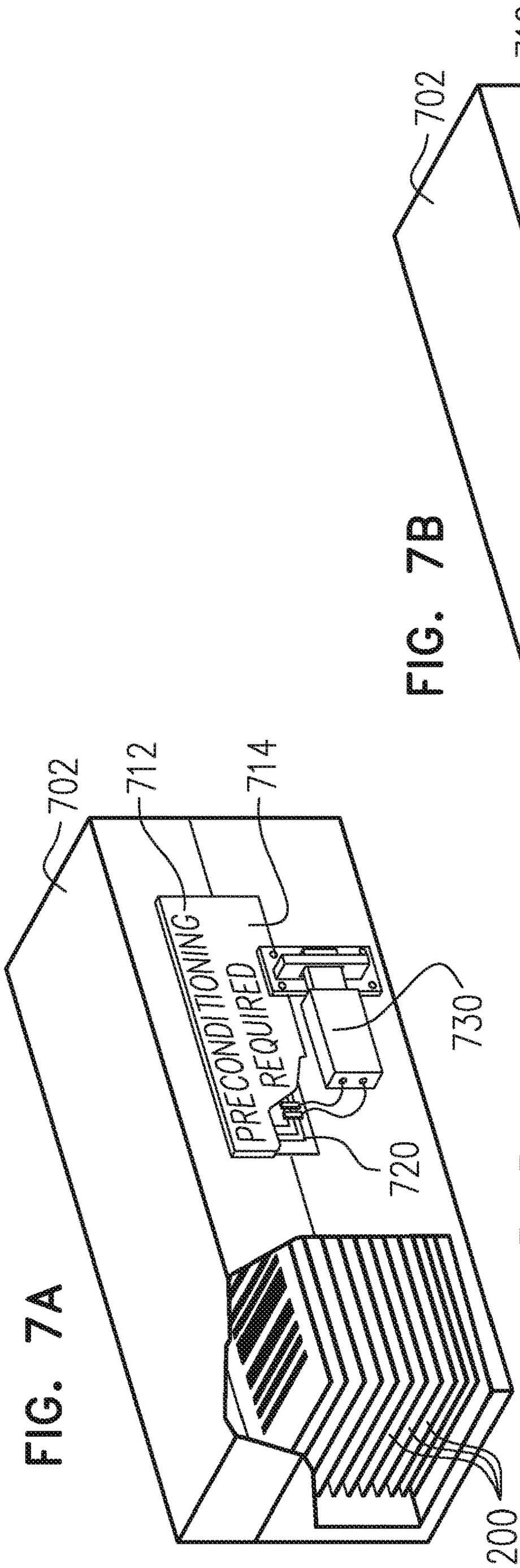
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FIG. 7A

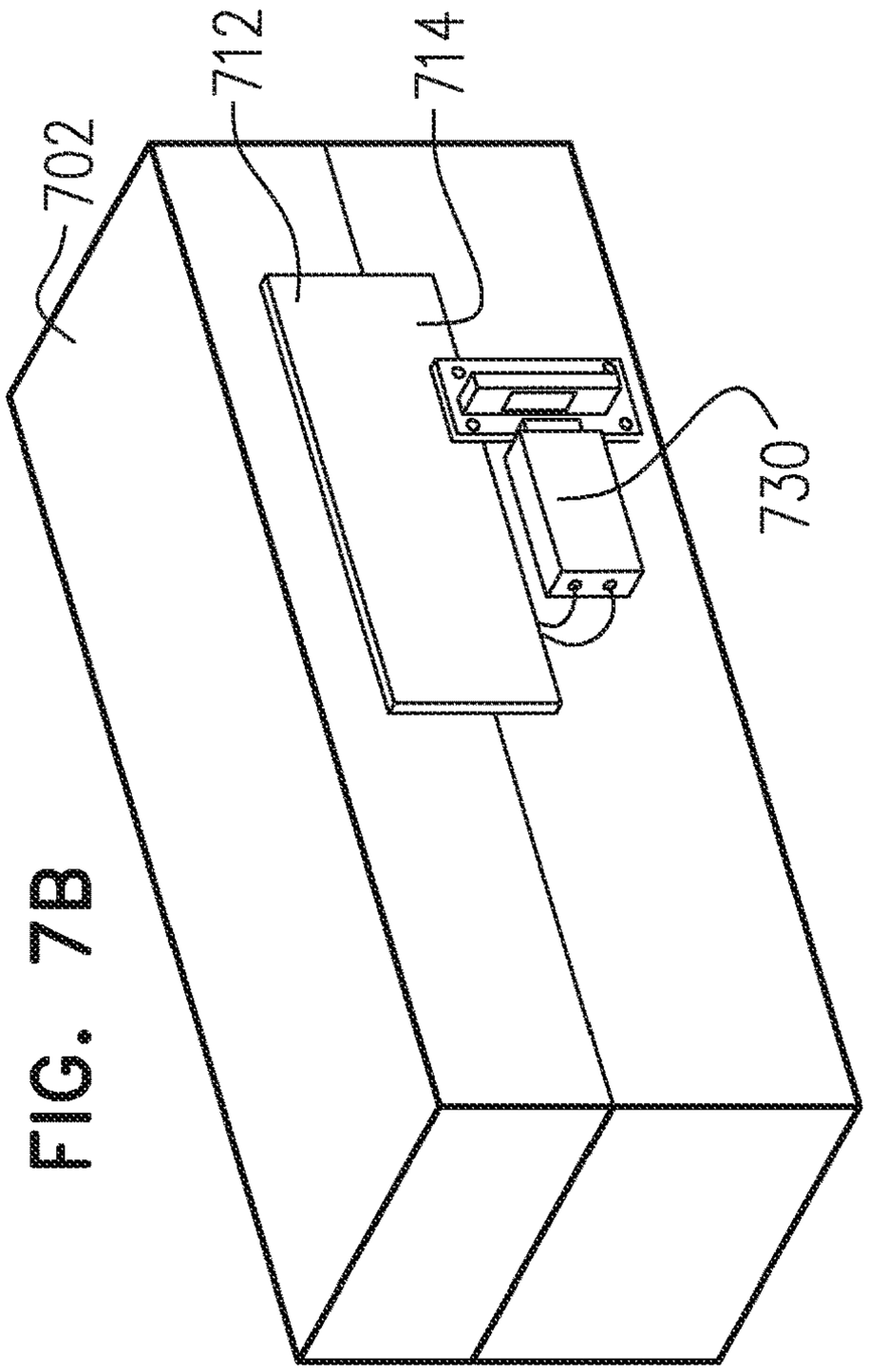
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FIG. 7B

THERMOCHROMIC INK INDICIA FOR ACTIVATABLE QUALITY LABELS

REFERENCE TO RELATED APPLICATIONS

The present application is a continuation application of U.S. patent application Ser. No. 15/574,353, filed Nov. 15, 2017, entitled "THERMOCHROMIC INK INDICIA FOR ACTIVATABLE QUALITY LABELS", now U.S. Pat. No. 11,060,924, which is a National Phase Application of International Patent Application No. PCT/IL2016/050526, filed May 18, 2016, entitled "THERMOCHROMIC INK INDICIA FOR ACTIVATABLE QUALITY LABELS", which claims priority of U.S. Provisional Patent Application 62/163,193, entitled THERMOCHROMIC INK INDICIA FOR QUALITY INDICATORS, filed May 18, 2015, the disclosures of which are hereby incorporated by reference.

Reference is also made to the following US Patents and Patent Applications, owned by the assignee, the disclosures of which are hereby incorporated by reference:

U.S. Pat. Nos. 7,562,811; 8,091,776; 8,807,422; 8,579,193; 8,540,156; 8,528,808; 8,196,821; 8,950,664; 8,500,014; and

U.S. Published Patent Application Nos. 2011/0006109; 2014/035385; 2014/0252096; 2015/0053776; 2012/0145781; 2013/0334301; and 2012/0104105.

FIELD OF THE INVENTION

The present invention relates generally to quality labels and more particularly to activatable quality labels.

BACKGROUND OF THE INVENTION

Various types of activatable quality labels are known in the art.

SUMMARY OF THE INVENTION

The present invention seeks to provide an improved activatable quality label including thermochromic ink indicia.

There is thus provided in accordance with a preferred embodiment of the present invention an activatable quality label operative to provide an indication of exceedance of a temperature threshold following activation thereof at a temperature less than or equal to an activation temperature, including a readable indicator located on the quality label and operative, following activation of the quality label at or below the activation temperature, to readably indicate exceedance of the temperature threshold, an actuator element operative to activate the quality label and indicia at least partially formed by thermochromic ink, the thermochromic ink having a first visual appearance at temperatures less than or equal to the activation temperature and a second visual appearance at temperatures above the activation temperature, such that a visual appearance of the indicia is indicative of whether the quality label is at a temperature less than or equal to the activation temperature and hence may be activated.

In accordance with a preferred embodiment of the present invention, the activatable quality label is applied to an item sensitive to exceedance of the temperature threshold, the readable indicator readably indicating exceedance of the temperature threshold by the item.

Preferably, the readable indicator includes a colorable readable indicator.

Preferably, the readable indicator includes a human-readable indicator.

Additionally or alternatively, the readable indicator includes a machine-readable indicator.

Preferably, the readable indicator includes a barcoded indicator.

Preferably, the barcoded indicator includes a multiplicity of barcodes.

Preferably, the multiplicity of barcodes includes a first barcode including at least one first colorable area, the first barcode being machine-readable before exceedance of the temperature threshold and at least a second barcode including at least one second colorable area, the second barcode not being machine-readable before exceedance of the temperature threshold.

Preferably, the barcoded indicator also includes a coloring agent located at a first location on the quality label and a coloring agent pathway located adjacent to the first location, the coloring agent pathway being operative, following the activation of the quality label, to allow the coloring agent to move, at a rate which is at least partially a function of time, from the first location to the first and second colorable areas simultaneously for simultaneous coloring thereof upon exceedance of the temperature threshold, thereby causing the first barcode to become unreadable and at the same or close to the same time causing the second barcode to become machine-readable.

Preferably, the actuator element includes a displaceable pull strip.

Preferably, the first visual appearance includes the thermochromic ink being of a first color and the second visual appearance includes the thermochromic ink being of a second color, different to the first color.

Preferably, the first visual appearance is visible and the second visual appearance is at least partially invisible.

Alternatively, the first visual appearance is at least partially invisible and the second visual appearance is visible.

Preferably, the visual appearance of the thermochromic ink reversibly changes between the first visual appearance at temperatures less than or equal to the activation temperature and the second visual appearance at temperatures above the activation temperature.

In accordance with a preferred embodiment of the present invention, the thermochromic ink changes from the first visual appearance to the second visual appearance at a temperature generally equal to the activation temperature.

Alternatively, the thermochromic ink changes from the first visual appearance to the second visual appearance at a temperature below the activation temperature.

Preferably, the indicia include human-readable indicia. Additionally or alternatively, the indicia include machine-readable indicia.

Preferably, the indicia include at least one barcode.

Preferably, the at least one barcode includes a first barcode being machine-readable at temperatures less than or equal to the activation temperature and unreadable at temperatures greater than the activation temperature and a second barcode being unreadable at temperatures less than or equal to the activation temperature and machine-readable at temperatures greater than the activation temperature.

Preferably, the indicia is directly located on the quality label.

Alternatively, the indicia is not directly located on the quality label.

There is additionally provided in accordance with another preferred embodiment of the present invention a method for providing an indication of exceedance of a temperature

threshold by an item, including providing an activatable quality label having a readable indicator formed at a first location thereon and thermochromic ink indicia formed at a second location with respect thereto, the readable indicator readably indicating exceedance of the temperature threshold following activation of the quality label at a temperature less than or equal to an activation temperature, the thermochromic ink indicia having a first visual appearance at temperatures less than or equal to the activation temperature and a second visual appearance at temperatures above the activation temperature, such that a visual appearance of the thermochromic ink indicia is indicative of whether the quality label is at a temperature less than or equal to the activation temperature, upon the thermochromic ink indicia indicating the quality label to be at a temperature less than or equal to the activation temperature, activating the quality label, and applying the activatable quality label to the item.

Preferably, the readable indicator includes a colorable readable indicator.

Preferably, the readable indicator includes a human-readable indicator.

Additionally or alternatively, the readable indicator includes a machine-readable indicator.

Preferably, the readable indicator includes a barcoded indicator.

Preferably, the barcoded indicator includes a multiplicity of barcoded.

Preferably, the multiplicity of barcodes includes a first barcode including at least one first colorable area, the first barcode being machine-readable before exceedance of the temperature threshold and at least a second barcode including at least one second colorable area, the second barcode not being machine-readable before exceedance of the temperature threshold.

Preferably, the barcoded indicator also includes a coloring agent located at a first location on the quality label and a coloring agent pathway located adjacent to the first location, the coloring agent pathway being operative, following the activation of the quality label, to allow the coloring agent to move, at a rate which is at least partially a function of time, from the first location to the first and second colorable areas simultaneously for simultaneous coloring thereof upon exceedance of the temperature threshold, thereby causing the first barcode to become unreadable and at the same or close to the same time causing the second barcode to become machine-readable.

Preferably, the method also includes providing an actuator element for activating the quality label.

Preferably, the actuator element includes a displaceable pull strip.

Preferably, the first visual appearance includes the thermochromic ink being of a first color and the second visual appearance includes the thermochromic ink being of a second color, different to the first color.

Preferably, the first visual appearance is visible and the second visual appearance is at least partially invisible.

Alternatively, the first visual appearance is at east partially invisible and the second visual appearance is visible.

In accordance with a preferred embodiment of the method of the present invention, the visual appearance of the thermochromic ink reversibly changes between the first visual appearance at temperatures less than or equal to the activation temperature and the second visual appearance at temperatures above the activation temperature.

Preferably, the thermochromic ink changes from the first visual appearance to the second visual appearance at a temperature generally equal to the activation temperature.

Alternatively, the thermochromic ink changes from the first visual appearance to the second visual appearance at a temperature below the activation temperature.

Preferably, the thermochromic ink indicia include human-readable indicia.

Additionally or alternatively, the thermochromic ink indicia include machine-readable indicia.

Preferably, the thermochromic ink indicia include at least one barcode.

In accordance with another preferred embodiment of the method of the present invention, the method also includes reading the barcoded indicator prior to the activating, reading the barcode including the thermochromic ink indicia following the reading of the barcoded indicator and prior to the activating, upon the barcode including the thermochromic ink indicia indicating the quality label to be at a temperature less than or equal to the activation temperature, activating the quality label and reading the barcoded indicator following the activating.

In accordance with yet another preferred embodiment of the method of the present invention, the at least one barcode includes a first barcode being machine-readable at temperatures less than or equal to the activation temperature and unreadable at temperatures greater than the activation temperature and a second barcode being unreadable at temperatures less than or equal to the activation temperature and machine-readable at temperatures greater than the activation temperature.

Preferably, the second location is directly located on the quality label.

Alternatively, the second location is not directly located on the quality label.

There is further provided in accordance with yet another preferred embodiment of the present invention an arrangement for indicating exceedance of a temperature threshold by an item including an item sensitive to exceedance of the temperature threshold and an activatable quality label applied to the item, the activatable quality label including a readable indicator located on the activatable quality label and operative, following activation of the quality label at an activation temperature, to readably indicate exceedance of the temperature threshold by the item, an actuator element operative to actuate the quality label, and indicia at least partially formed by thermochromic ink, the thermochromic ink having a first visual appearance at temperatures less than or equal to the activation temperature and a second visual appearance at temperatures above the activation temperature, such that a visual appearance of the indicia is indicative of whether the quality label is at a temperature less than or equal to the activation temperature and hence may be activated.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

FIGS. **1**A, **1**B and **1**C are simplified respective schematic illustrations of first, second and third states of an activatable quality label constructed and operative in accordance with a preferred embodiment of the present invention;

FIG. **2**A is a simplified schematic exploded view illustration of an activatable quality label constructed and operative in accordance with another preferred embodiment of the present invention, showing a first state thereof;

FIG. **2**B is a simplified schematic assembled view illustration of the activatable quality label of FIG. **2**A, showing a second state thereof;

FIGS. **3**A and **3**B are simplified pictorial illustrations of steps in the activation and application of an activatable quality label of the type shown in FIGS. **2**A and **2**B;

FIGS. **4**A and **4**B are simplified respective schematic illustrations of first and second states of an activatable quality label constructed and operative in accordance with a further preferred embodiment of the present invention;

FIGS. **5**A and **5**B are simplified respective schematic illustrations of first and second states of an activatable quality label constructed and operative in accordance with yet a further preferred embodiment of the present invention;

FIGS. **6**A and **6**B are simplified respective schematic illustrations of first and second states of an activatable quality label, constructed and operative in accordance with yet another preferred embodiment of the present invention; and

FIGS. **7**A and **7**B are simplified respective schematic illustrations of first and second states of a plurality of activatable quality labels, constructed and operative in accordance with a still further preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is now made to FIGS. **1**A, **1**B and **1**C, which are simplified respective schematic illustrations of first, second and third states of an activatable quality label, constructed and operative in accordance with a preferred embodiment of the present invention.

As seen in FIGS. **1**A-**1**C, there is provided an activatable quality label **100**, preferably operative to provide an indication of exceedance of a temperature threshold following activation thereof. Quality label **100** is preferably of a type requiring cooling to a given activation temperature prior to activation thereof. The process of cooling quality label **100** to at or below the activation temperature may be termed preconditioning and the activation temperature may therefore also be termed the precondition temperature of quality label **100**. The terms activation temperature and precondition temperature are thus used interchangeably herein. Various types of quality labels requiring preconditioning prior to activation thereof are known in the art.

Quality label **100** may be suitable for direct or indirect application to any item benefitting from an indication of the temperature status and/or history thereof, such as, by way of example only, medical equipment, vaccines and food products. Alternatively, quality label **100** may be used to monitor ambient temperature and/or time at temperature conditions, in which case quality label **100** may be a stand-alone product adapted for independent use, without requiring application to an item to be monitored.

Quality label **100** preferably includes at least one readable indicator region **102** located thereon, readably indicating exceedance of a temperature threshold preferably following activation of the quality label **100** at or below the activation temperature of quality label **100**. The temperature threshold, exceedance of which is indicated by indicator region **102**, is typically greater than the precondition temperature although it is appreciated that the temperature threshold may alternatively be generally equal to the precondition temperature. Indicator region **102** may be embodied as any indicator capable of providing a readable indication of exceedance of a temperature threshold, various types of which are known in the art, including colorable temperature and time-temperature indicators.

Here, by way of example only, indicator region **102** is shown to be embodied as a colorable indicator region **102** located at a first location on a surface of quality label **100**. It is appreciated that colorable region **102** is shown in a highly simplified form in FIGS. **1**A-**1**C, for the sake of clarity and generality of presentation thereof, and that colorable region **102** may comprise more than one colorable region having a more intricate structure, including, by way of example, multiple colorable windows. It is further appreciated that colorable region **102** may additionally or alternatively form a portion of a more extensive marking or indicia. Thus, by way of example, colorable region **102** may comprise a portion of a printed barcode, as will be exemplified henceforth with reference to FIGS. **2**A-**7**B.

Colorable region **102** is preferably adapted for coloring following activation of quality label **100** at a temperature less or equal to the precondition temperature of quality label **100** and upon exceedance of the temperature threshold. Coloring of colorable region **102** may occur by way of diffusion of a temperature-dependent coloring agent included in quality label **100** or by any other mechanism known in the art.

Quality label **100** may be activated by way of an actuator element **104**, which actuator element **104** is preferably operative to actuate quality label **100** such that colorable indicator region **102** becomes operative. It is appreciated that prior to the activation of quality label **100**, indicator region **102** is preferably disabled and is generally non-responsive to changes in temperature. Actuator element **104** may be embodied as a displaceable strip for activating quality indicator **100** upon displacement thereof, as shown herein by way of example. It is understood, however, that actuator element **104** may comprise any element and/or mechanism suitable for activating quality label **100**, including rigid, flexible, film and/or foil elements as are known in the art.

It is appreciated that in order for quality label **100** to provide an accurate and reliable indication of exceedance of a predetermined temperature threshold by an item to which quality label **100** may be affixed, quality label **100** is required to be activated only following being cooled to a temperature less than or equal to the activation temperature of quality label **100**. Quality label **100** must therefore be preconditioned to a temperature less than or equal to the activation temperature prior to activation thereof. Should quality label **100** be activated without cooling and at a temperature above the precondition temperature, the reading provided by indicator region **102** may not be an accurate indication of possible exceedance of the temperature threshold by the item or environment with which quality label **100** is associated.

In order to facilitate activation of quality label **100** at a temperature less than or equal to the activation temperature, quality label **100** preferably includes indicia at least partially formed by thermochromic ink. The thermochromic ink forming the indicia preferably has a first visual appearance at temperatures less than or equal to the activation temperature and a second visual appearance, different to the first visual appearance, at temperatures above the activation temperature, the visual appearance of the indicia thus indicating whether quality label **100** is at or below the activation temperature and hence may be actuated.

Referring now to a first state of quality label **100** shown in FIG. **1**A, quality label **100** is at a temperature T above the

activation temperature $T_{precondition}$ and thus not ready for activation. A thermochromic ink indicium may be printed on actuator element **104** in a region **108** thereon. Here, region **108** within which thermochromic ink indicium is located is generally indicated by a boundary **110**. It is appreciated, however, that boundary **110** is a conceptual boundary only and does not correspond to a visible, physical boundary on actuator element **104**. As evident from consideration of the appearance of actuator element **104** in FIG. **1**A, the thermochromic ink indicium is not visible when quality label **100** is in this temperature state. It is appreciated that in this first state of quality label **100**, prior to activation thereof, colorable indicator region **102** is generally non-responsive to changes in temperature and here, by way of example, is shown to be clear.

Upon label **100** being cooled or preconditioned to a temperature less than or equal to $T_{precondition}$, corresponding to a second state of label **100** shown in FIG. **1**B, a thermochromic ink indicium **112** printed on actuator element **104** in region **108** thereof becomes visible. In this case, by way of example, the thermochromic ink indicium **112** may be a printed text reading 'READY TO ACTIVATE' upon label **100** being cooled to a temperature below the precondition temperature.

By way of example, the thermochromic ink marking **112** may comprise an ink having a white color at a temperature above $T_{precondition}$ and having a blue color at a temperature less than or equal to $T_{precondition}$. In the case that actuator element **104** is of a white color in region **108**, the thermochromic ink marking **112** is thus not visible in region **108** at a temperature above $T_{precondition}$ since the color of the ink is generally the same as the background color of the region on which the ink is located. Actuator element **104** thus appears to be blank, as seen in FIG. **1**A. Following preconditioning, at a temperature less than or equal to $T_{precondition}$, the thermochromic ink becomes blue and therefore readable, as seen in FIG. **1**B.

Additionally by way of example, the thermochromic ink marking **112** may comprise an ink that is transparent at a temperature above $T_{precondition}$ and of a black or grey color at a temperature less than $T_{precondition}$. In this case, the thermochromic ink marking **112** is transparent and thus not visible in region **108** at a temperature above $T_{precondition}$ as seen in FIG. **1**A, and becomes visible and hence readable upon being cooled to a temperature less than or equal to $T_{precondition}$, as seen in FIG. **1**B. An advantage of using thermochromic ink that is transparent rather than colored at temperatures greater than $T_{precondition}$ is that the thermochromic ink indicia **112** will not visible at temperatures above $T_{precondition}$ independent of the color of the surface on which the thermochromic ink indicia **112** are formed.

As seen in FIG. **1**B, the thermochromic ink **112** may display a human-readable textual message instructing a user that label **100** is ready to activate. It is appreciated that thermochromic ink **112** may alternatively be printed or otherwise formed on actuator element **104** so as to display a machine readable message indicating that label **100** is ready to activate, as will be exemplified henceforth.

Thermochromic ink indicium **112** may be at least partially invisible at temperatures less than or equal to $T_{precondition}$, as shown to be the case in FIG. **1**A in which indicia **112** are invisible, and may become visible at temperatures above $T_{precondition}$. Alternatively, indicia **112** may be visible at temperatures less than or equal to $T_{precondition}$ and become at least partially invisible at temperatures above $T_{precondition}$ and the message displayed thereby modified accordingly, as will be exemplified henceforth.

Following an indication by thermochromic ink indicia **112** of label **100** having been preconditioned and being at or below $T_{precondition}$, quality label **100** may be activated, as seen in FIG. **1**C. Here, by way of example, quality label **100** is shown to be activated by removal of activation element **104** therefrom. Upon removal of activation element **104** from label **100**, colorable indicator region **102** preferably becomes active and responsive to changes in temperature and thus capable of indicating exceedance of a temperature threshold $T_{threshold}$. As seen in FIG. **1**C showing quality label **100** in a third state, at a temperature above the temperature threshold, colorable region **102** may change from clear to colored, thus providing a readable visual indication of exceedance of the temperature threshold.

Preferably, the thermochromic ink forming indica **112** is of a reversible type, such that following a change of color upon being preconditioned and cooled to at or below a precondition temperature, the thermochromic ink may revert to its previous color upon exceedance thereof. Thus, as seen in FIG. **1**C, the message 'READY TO ACTIVATE' is no longer visible upon actuation element **104**, due to actuation element **104** now having returned to a temperature above $T_{precondition}$ and the thermochromic ink indicia **112** therefore having resumed the same appearance as in the first state thereof, corresponding to that shown in FIG. **1**A.

The use of reversible thermochromic ink may be particularly advantageous when quality label **100** is used in fluctuating temperature conditions, since this allows indicia **112** to reversibly change appearance multiple times during preconditioning and prior to activation of quality label **100** by a user. Reversible thermochromic inks suitable for use in the present invention are commercially available from a variety of manufacturers, including 'B and H Color Change' of Flintshire, UK and 'Chromatic Technologies, Inc.' of Colorado, USA.

It is appreciated that the thermochromic ink used to form indicia **112** may be selected so as to be of a type undergoing a change in visual appearance, such as a color change, at a temperature generally equal to the precondition temperature of label **100** or of a type undergoing a visual change, such as a color change, at a temperature several degrees below the precondition temperature. so as to provide an error margin in the activation of label **100**.

Thermochromic ink indicia **112** may be formed at a variety of locations on label **100** by way of printing, stamping or other means as are well known in the art. It is appreciated that the location of region **108** and indicia **112** on actuator element **104** shown in FIG. **1**B is by way of example only, and that indicia **112** may alternatively be formed at a variety of other locations on the body of label **100**. It is further appreciated that indicia **112** are not necessarily directly formed on label **100** and may alternatively be formed on another surface separate from but associated with label **100**, as will be exemplified henceforth with reference to FIGS. **7**A and **7**B.

It is appreciated that quality label **100** thus preferably includes two distinct indicators, the first indicator being the thermochromic ink indicia **112** indicating quality label to be preconditioned to a temperature less than or equal to a precondition temperature of quality label **100** and thus ready for activation, the second indicator being indicator region **102**. Indicator region **102** is preferably activated by a user in response to the indication of readiness for activation by the first thermochromic indicator **112**. Upon indicator region **102** being activated, indicator region **102** provides an indication of exceedance of a threshold temperature by the

quality label **100** itself or by an item to which quality label **100** may be affixed, in order to monitor the temperature status thereof.

Reference to now made to FIG. **2**A, which is a simplified schematic exploded view illustration of an activatable quality label constructed and operative in accordance with another preferred embodiment of the present invention, showing a first state thereof, and to FIG. **2**B, which is a simplified schematic assembled view illustration of the activatable quality label of FIG. **2**A, showing a second state thereof.

As seen in FIG. **2**A, there is provided a quality label **200**, preferably operative to provide an indication of exceedance of a temperature threshold following activation thereof. Quality label **200** is preferably of a type requiring cooling to a given activation temperature prior to activation thereof. The process of cooling quality label **200** to at or below the activation temperature may be termed preconditioning and the activation temperature may therefore also be termed the precondition temperature of quality label **200**.

Quality label **200** preferably includes at least one indicator region **202** operative to readably indicate exceedance of a temperature threshold following activation of the quality label **200** at or below the activation temperature of quality label **200**. The temperature threshold, exceedance of which is indicated by indicator region **202**. is typically greater than the precondition temperature although it is appreciated that the temperature threshold may alternatively be generally equal to the precondition temperature. Here, indicator region **202** is shown to be embodied as a barcoded indicator region **202** including multiple colorable regions **204** forming part of a multiplicity of barcodes **206**. Barcodes **206** may be printed on a barcode defining layer **208**, preferably formed on a transparent substrate. It is appreciated that the particular configuration of barcodes **206** is illustrative only and that the scope of the present invention includes any other type of barcodes comprising colorable regions, as are known in the art.

Colorable regions **204** are preferably adapted for coloring following activation of quality label **200** at a temperature less than or equal to the precondition temperature and upon exceedance of the temperature threshold. Coloring of colorable regions **204** may occur by way of diffusion of a temperature-dependent coloring agent **210** located at a first location on quality label **200** along a coloring agent pathway **212** adjacent thereto.

Quality label **200** may be activated by way of an actuator element, here embodied as an actuation pull strip **220**. Actuation pull strip **220** is preferably operative to activate quality label **200** such that barcoded indicator region **202** becomes operative and responsive to temperature changes. It is appreciated that prior to the activation of quality label **200**, barcoded indicator region **202** is preferably generally non-responsive to changes in temperature and barcodes **206** may be unreadable. Actuation pull strip **220** may be embodied as a displaceable pull strip for actuating quality label **200** upon removal thereof.

Quality label **200** is generally of type described, inter alia, in U.S. Pat. No. 8,091,776 of the applicant, which is incorporated herein by reference. Thus, multiplicity of barcodes **206** may include a first barcode including at least one first colorable area, the first barcode being machine-readable before exceedance of the temperature threshold and at least a second barcode including at least one second colorable area, the second barcode not being machine-readable before exceedance of the temperature threshold. Coloring agent pathway **212** may be operative, following activation of quality label **200**, to allow coloring agent **210** to move, at a rate which is at least partially a function of time, from the first location to the first and second colorable areas simultaneously for simultaneous coloring thereof upon exceedance of the temperature threshold, thereby causing the first barcode to become unreadable and at the same or close to the same time causing the second barcode to become machine-readable.

It is appreciated that in order for quality label **200** to provide an accurate and reliable indication of exceedance of a predetermined temperature threshold by an item to which quality label **200** may be affixed, quality label **200** is required to be activated at a temperature less than or equal to the activation temperature of quality label **200**. Quality label **200** must therefore be preconditioned to a temperature less than or equal to the activation temperature prior to activation thereof. Should quality label **200** be activated at a temperature above the precondition temperature, the reading provided by colorable barcodes **206** of indicator region **202** may not be an accurate indication of possible exceedance of the temperature threshold by the item or environment with which quality label **200** is associated.

In order to facilitate activation of quality label **200** at a temperature below the precondition temperature, quality label **200** preferably includes indicia at least partially formed by thermochromic ink. The thermochromic ink comprising the readable indicia preferably has a first visual appearance at temperatures less than or equal to the activation temperature of label **200** and a second visual appearance above the activation temperature, such that the indicia is readable to indicate whether label **200** is below the activation temperature and thus may be activated.

Referring now to a first exploded view of quality label **200** in FIG. **2**A, quality label **200** is in a first state at a temperature T above the activation temperature $T_{precondition}$ and thus not ready for activation. A thermochromic ink indicium may be printed on actuator element **220** in a region **222** thereof. As evident from consideration of the appearance of actuator element **220** in FIG. **2**A, the thermochromic ink indicium is not visible when quality label **200** is in this temperature state.

Upon label **200** being cooled or preconditioned to a temperature less than or equal to $T_{precondition}$, corresponding to a second state of label **200** shown in a second assembled view of quality label **200** in FIG. **2**B, thermochromic ink indicia **230** printed on actuation pull strip **220** in region **222** thereof become visible. In this case, by way of example, the thermochromic ink indicia **230** may be a printed text reading 'OK TO ACTIVATE' when at a temperature below the precondition temperature.

By way of example, the thermochromic ink marking **230** may comprise an ink having a white color at a temperature above $T_{precondition}$ and having a blue color at a temperature less than or equal to $T_{precondition}$. In the case that actuation pull strip **220** is of a white color in region **222**, the thermochromic ink marking **230** is thus not visible in region **222** at a temperature above $T_{precondition}$ since the color of the ink is generally the same as the background color of the region on which the ink is located. Actuation pull strip **220** thus appears to be blank, as seen in FIG. **2**A. At a temperature less than or equal to $T_{precondition}$, the thermochromic ink becomes blue and therefore readable, as seen in FIG. **2**B.

Alternatively, the thermochromic ink marking **230** may comprise an ink that is transparent at temperatures above $T_{precondition}$ and of a black or grey color at temperatures less than or equal to $T_{precondition}$, in which case the thermochro-

mic ink marking **230** will not be visible in region **222** at a temperature above $T_{precondition}$, independent of the background color of region **222**.

In this case, by way of example, the thermochromic ink indicia **230** display a human-readable textual message instructing a user that label **200** is preconditioned and ready to activate. Consequently, label **200** may be activated by removal of actuator element **220** therefrom, thus rendering indicator region **202** active and responsive to changes in temperature.

It is appreciated that the thermochromic ink indicia **230** may alternatively be printed or otherwise formed on actuator element **220** so as to display a machine-readable message indicating that indicator **200** is ready to activate, as will be exemplified henceforth.

Thermochromic ink indicia **230** may be at least partially invisible at temperatures less than or equal to $T_{precondition}$, as shown to be the case in FIG. **2**A in which indicia **230** are invisible, and may become visible at temperatures above $T_{precondition}$ Alternatively, indicia **230** may be visible at temperatures less than or equal to $T_{precondition}$ and become at least partially invisible at temperatures above $T_{precondition}$ and the message displayed thereby modified accordingly, as will be exemplified henceforth.

Preferably, the thermochromic ink is of a reversible type, such that following a change of color upon quality label being cooled to a temperature at or below the precondition temperature, the thermochromic ink may revert to its previous color upon exceedance thereof. Reversible thermochromic inks of these types are commercially available from a variety of manufacturers, including 'B and H Color Change' of Flintshire, UK and 'Chromatic Technologies, Inc.' of Colorado, USA.

The thermochromic ink used to form indicia **230** may be selected so as to be of a type undergoing a change in visual appearance, such as a color change, at a temperature generally equal to the precondition temperature of label **200** or of a type undergoing a visual change, such as a color change, at a temperature several degrees below the precondition temperature of label **200**, so as to provide an error margin in activation of label **200**.

Thermochromic ink indicia **230** may be formed at a variety of locations on label **200** by way of printing, stamping or other means as are well known in the art. It is appreciated that the location of region **222** and indicia **230** on actuator element **220** shown in FIG. **2**B is by way of example only, and that indicia **230** may alternatively be formed at a variety of other locations on the body of label **200**. It is further appreciated that indicia **230** are not necessarily directly formed on label **200** and may alternatively be formed on another surface separate from but associated with label **200**, as will be exemplified henceforth with reference to FIGS. **7**A and **7**B.

It is appreciated that quality label **200** thus preferably includes two distinct indicators, the first indicator being the thermochromic ink indicia **230** indicating quality label to be preconditioned to a temperature less than or equal to a precondition temperature of quality label **200** and thus ready for activation, the second indicator being colorable barcoded regions **206** of indicator region **202**. Indicator region **202** is preferably activated by a user in response to the indication of readiness for activation by the first thermochromic indicator **230**. Upon indicator region **202** being activated, indicator region **202** provides an indication of exceedance of a threshold temperature by the quality label **200** itself or by an item to which quality label **200** may be affixed, in order to monitor the temperature status thereof.

Reference is now made to FIGS. **3**A and **3**B, which are simplified pictorial illustrations of steps in the activation of an activatable quality label of the type shown in FIGS. **2**A and **2**B.

As seen in FIG. **3**A, at a temperature T less than or equal to $T_{precondition}$ thermochromic ink indicia **230** on quality label **200** display a visual indication of quality label **200** having been preconditioned and hence being ready for activation. Here, by way of example, thermochromic ink indicia **230** on actuation pull strip **220** display a human-readable message 'OK TO ACTIVATE'. Upon display of this message, a user may remove actuation pull strip **220** by pulling thereon, as indicated by a numeral **300**, so as to render quality label **200** active and barcoded indicator region **202** responsive to changes in temperature.

As seen in FIG. **3**B, subsequent to removal of actuation pull strip **220** and consequent activation of quality label **200**, quality label **200** may be applied by the user to an item to be monitored, such as an item **302**. Item **302** is a temperature-sensitive item, sensitive to exceedance of the threshold temperature. Following the application of quality label **200** to item **302**, indicator region **202** is preferably operative to readably indicate exceedance of the temperature threshold by item **302**.

It is understood that the steps in activation of quality label **200** shown in FIGS. **3**A and **3**B are not required to be performed in the sequence shown and may alternatively be reversed. Thus, quality label **200** may first be applied to item **302**, as shown in FIG. **3**B and only subsequently be activated, as shown in FIG. **3**A. Furthermore, it is understood that the step of application of quality label **200** to a temperature-sensitive item to be monitored may be obviated if quality label **200** is to be used as an ambient quality indicator. Additionally, it is appreciated that although the steps in activation of a quality label of the present invention are illustrated in FIGS. **3**A and **3**B with respect to quality label **200**, these steps may be applied to any quality label constructed and operative in accordance with preferred embodiments of the present invention, with modifications and/or additional steps as may be required.

It will be appreciated that the particular configurations and visual appearances of thermochromic ink indicia **212**, **230** at temperatures above and below the precondition temperature, as shown in FIGS. **1**A-**3**A, are illustrative only and that a large variety of alternative configurations of thermochromic ink indicia indicating satisfaction of preconditioning requirements and hence readiness for activation of quality labels of the present invention, are also possible.

Thus, by way of example as seen in FIG. **4**A, when quality label **200** is in a first state at a temperature T above the precondition temperature $T_{precondition}$ and thus not ready for activation, thermochromic ink indicia **430** may be configured to display a message 'NOT OK TO ACTIVATE'.

The word 'NOT' may be printed using regular, non-thermochromic ink in a region **442** of actuator element **220** on a background region **444**, background region **444** being formed of thermochromic ink. By way of example, the thermochromic ink used to form background region **444** may be white at temperatures above the precondition temperature and may turn blue at temperatures less than or equal to the precondition temperature. The word 'NOT' may be printed in blue ink. Additional text 'OK TO ACTIVATE' may be printed adjacent to the word 'NOT' in regular, non-thermochromic ink.

At temperatures above $T_{precondition}$, as seen in FIG. **4**A, the word 'NOT' in blue is visible against the white thermochromic ink background **444** and indicator **200** therefore

bears the indicia 'NOT OK TO ACTIVATE'. Upon indicator **200** being cooled to a temperature less than or equal to $T_{precondition}$, corresponding to a state of indicator **200** shown in FIG. **4**B, the word 'NOT' is no longer visible since the thermochromic ink forming background **444** has assumed a blue color, thus masking the presence of the blue text 'NOT'. The indicator, once cooled to a temperature equal to or less than the precondition temperature, hence bears the text 'OK TO ACTIVATE'.

It will be appreciated that thermochromic ink indicia **230**, **430** on actuator element **220** is not limited to being a human-readable indicia. Thus, as shown in FIGS. **5**A and **5**B, thermochromic ink may be used to form a barcoded thermochromic ink indicia **550** on actuator element **220** alongside the text message **430**. Barcoded thermochromic ink indicia **550** may become machine-readable at temperatures less than or equal to the precondition temperature, as seen in FIG. **5**B. A particular advantage of the embodiment shown in FIGS. **5**A and **5**B is that the barcoded thermochromic ink indicia **550** is machine-readable and thus may be read by means of a barcode scanner so as to confirm correct activation of the label **200**.

In a particularly preferred embodiment of the present invention, barcode **550** may be read sequentially with barcodes **206** in order to verify that quality label **200** was correctly preconditioned prior to activation thereof and hence that the reading provided by quality label **200** is accurate.

By way of example, a barcode scanner may be used to scan barcodes **206**, prior to activation of quality label **200**. Prior to activation of quality label **200** barcodes **206** are preferably indicative that quality label **200** has not yet been activated, either by being unreadable or by at least one of multiplicity of barcodes **206** being readable. The reading of barcodes **206** thus may be used to confirm that quality label **200** has not yet been activated.

Following the scanning of barcodes **206**, barcode **550** may be scanned, in order to confirm that quality label **200** has been cooled to the precondition temperature and may be activated. Upon confirmation that quality label **200** has been correctly preconditioned and is at a temperature at or below the precondition temperature, quality label **200** may be activated by removal of actuation pull strip **220**.

Subsequently, following activation, barcodes **206** may again be scanned by a barcode scanner. Following activation of quality label **200** barcodes **206** are preferably indicative that quality label has been activated, due to a change in at least one of multiplicity of barcodes **206** upon activation of quality label **200**. The post-activation reading of barcodes **206** thus may confirm that quality label **200** has been activated.

The barcode scanner may record the time at which barcode **550** is read and the time at which barcodes **206** are subsequently read, following activation. Provided that only a short time has been found to elapse between the reading of barcode **550** followed by barcodes **206**, it may be assumed that no significant change in temperature of quality label **200** occurred between the two readings, thereby verifying that quality label **200** was activated at or below the required precondition temperature and that the reading provided by quality label **200** is hence reliable.

In order to facilitate the above-described verification of correct activation of quality label **200** by sequential reading of barcode **550** in conjunction with barcodes **206**, barcode **550** may be stored in a database and is preferably unique to the quality label with which it is associated.

In one preferred embodiment, the barcoded thermochromic indicia **550** may be at least partially invisible at temperatures above $T_{precondition}$, as shown in FIG. **5**A, and may become visible only upon indicator **200** being cooled to a temperature at or below $T_{precondition}$, as shown in FIG. **5**B. Alternatively, barcoded thermochromic indicia **550** may be at least partially invisible at temperatures less than or equal to $T_{precondition}$ and become visible at temperatures greater than $T_{precondition}$. Barcoded indicia **550** may be applied in conjunction with a human readable text message, such as message **430** as shown in FIGS. **5**A and **5**B. Alternatively, barcoded thermochromic indicia **550** may replace the human readable text message.

Barcoded thermochromic indicia **550** are not limited to comprising a single barcode. As seen in FIGS. **6**A and **6**B, a thermochromic barcoded region located on indicator **200** may include a first barcode **650** seen in FIG. **6**A and a second barcode **660**, seen in FIG. **6**B, both of which first and second barcodes **650** and **660** are at least partially formed by thermochromic ink. One of barcodes **650** and **660**, for example barcode **650**, may be formed by thermochromic ink so as to be visible only at temperatures above the precondition temperature, for example above 0° C. The other one of barcodes **650** and **660**, for example barcode **660**, may be formed of a different type of thermochromic ink being visible only at temperatures less than the precondition temperature, for example below −3° C. The reading of either one of barcodes **650** or **660** with a barcode scanner therefore may be used to indicate whether the quality label has been preconditioned to the precondition temperature and hence is ready for activation.

In a particularly preferred embodiment of the present invention, barcodes **650** and **660** may be read sequentially with barcodes **206** in order to verify that quality label **200** was correctly preconditioned prior to activation thereof and hence that the reading provided by quality label **200** is accurate.

By way of example, a barcode scanner may be used to scan barcodes **206**, prior to activation of quality label **200**. Prior to activation of quality label **200** barcodes **206** are preferably indicative that quality label **200** has not yet been activated, either by being unreadable or by at least one of multiplicity of barcodes **206** being readable. The reading of barcodes **206** thus may be used to confirm that quality label **200** has not yet been activated.

Following the scanning of barcodes **206**, barcode **650**/**660** may be scanned, in order to confirm that quality label **200** has been cooled to the precondition temperature and may be activated. The reading of barcode **660** may confirm that quality label **200** has been correctly preconditioned and is at a temperature at or below the precondition temperature. Quality label **200** may then be activated by removal of actuation pull strip **220**.

Subsequently, following activation, barcodes **206** may again be scanned by a barcode scanner. Following activation of quality label **200** barcodes **206** are preferably indicative that quality label has been activated, by a change in at least one of multiplicity of barcodes **206**. The post-activation reading of barcodes **206** thus may confirm that quality label **200** has been activated.

The barcode scanner may record the time at which barcode **660** is read and the time at which barcodes **206** are subsequently read, following activation. Provided that only a short time has been found to elapse between the reading of barcode **660** followed by barcodes **206**, it may be assumed that no significant change in temperature of quality label **200** occurred between the two readings, thereby verifying that

quality label **200** was activated at or below the required precondition temperature and that the reading provided by quality label **200** is hence reliable.

In order to facilitate the above-described verification of correct activation of quality label **200** by sequential reading of barcodes **650**/**660** in conjunction with barcodes **206**, barcodes **650**/**660** may be stored in a database and are preferably unique to the quality label with which they are associated.

It is appreciated that it is possible that at a given temperature, such as for example, −2° C., both of barcodes **650** and **660** may be visible and hence readable or alternatively both of barcodes **650** and **660** may be invisible and hence unreadable. In this case, a message may be displayed on the screen of the barcode scanner indicating that the quality label requires further cooling in order for the quality label **200** to be accurately activated.

It is appreciated that thermochromic barcoded regions **550**, **650** and **660**, preferably correspond to standard machine readable barcodes of types well known in the art. It is further appreciated that barcoded regions **550**, **650** and **660** may be used in conjunction with human-readable text thermochromic ink indicia messages, such as 'OK TO ACTIVATE' as shown in FIGS. **4**A-**5**B, or may be used without the presence of other additional thermochromic ink indicia.

It is additionally appreciated that the thermochromic ink used to form the barcoded thermochromic indicia may be selected so as to be of a type undergoing a color change at a temperature generally equal to the precondition temperature of the label or of a type undergoing a color change at a temperature several degrees below the precondition temperature of the label, so as to provide an error margin in activation of quality label **200**.

Thermochromic ink indicia may be formed at a variety of locations on quality label **200** by way of printing, stamping or other means as are well known in the art. It is appreciated that the location of the indicia on actuator element **220** as shown in FIGS. **2**A-**6**B is by way of example only, and that the indicia may alternatively be formed at other locations on the body of label **200**. Thus, by way of example, all or some of barcodes **206** may be printed using thermochromic ink, such that an appearance of at least one of barcodes **206** is machine readably indicative of whether quality indicator **200** is below the precondition temperature and hence may be activated. Additionally, a thermochromic ink text such as 'TEMPERATURE OK' may be printed on barcode defining layer **208**, which text may become visible only at temperatures below the precondition temperature, so as to readably indicate the present temperature of the quality indicator.

It is appreciated that the invention described herein may be incorporated in any type of quality label or quality indicator. Particularly preferably, the invention described herein may be incorporated in one of the barcodes described in any one of related applications U.S. Pat. Nos. 7,562,811; 8,091,776; 8,807,422; 8,579,193; 8,540,156; 8,528,808; 8,196,821; 8,950,664; 8,500,014; and U.B. Published Patent Application Nos. 2011/0006109; 2014/0353385; 2014/0252096; 2015/0053776; 2012/0145781; 2013/0334301; and 2012/0104105, all of which are incorporated by reference, with any such modifications as may be obvious to one skilled in the art.

Reference is now made to FIGS. **7**A and **7**B, which are simplified respective schematic illustrations of first and second states of a plurality of activatable quality labels, constructed and operative in accordance with a still further preferred embodiment of the present invention.

As seen in FIG. **7**A, a multiplicity of activatable quality labels **200** may be housed in a container **702**. Here, by way of examples, multiplicity of quality labels **200** is seen to comprise a large number of individual quality labels of a type generally resembling those shown in FIGS. **2**A-**6**B. It is appreciated, however, that multiplicity of quality labels **200** may comprise any type of activatable quality label requiring preconditioning prior to activation and including a readable indicator readably indicating exceedance of a temperature threshold following activation of the quality label.

In the case of a large number of quality labels such as shown in FIG. **7**A the cooling of the quality labels to below the precondition temperature prior to activation thereof may be performed on the multiplicity of quality labels **200** simultaneously. In such a case, it may be advantageous for the thermochromic ink indicia indicating readiness of the quality labels for activation below the precondition temperature to be located on container **702** rather than directly applied to each individual quality label.

In accordance with one possible preferred embodiment of the present invention, thermochromic ink indicia **712** may be applied to the outside of container **702** at a location **714**. As seen in FIG. **7**A, when multiplicity of quality labels **200** is at a temperature above $T_{precondition}$ the thermochromic indicia **712** may be visible and may display a human-readable message indicating that preconditioning is required. By way of example, the thermochromic ink indicia **712** may comprise an ink having a white color at a temperature less than or equal to $T_{precondition}$ and having a blue color at a temperature above $T_{precondition}$. In the case that container **702** is of a white color in region **714**, the thermochromic ink marking **712** thus is visible in region **714** when container **702** is at a temperature above $T_{precondition}$ since the color of the ink forms a contrast with the background color of the region on which the ink is located.

As seen in FIG. **7**B, when multiplicity of quality labels **200** is cooled to a temperature less than or equal to $T_{precondition}$ thermochromic ink indicia **712** may become invisible, since the white color of the indicia **712** at these temperatures is generally the same as the white background in region **714**.

It is understood that alternatively thermochromic ink indicia may be applied of the converse type so as to only become visible at temperatures equal to or less than the activation temperature. In this case, the thermochromic ink indicia may read, for example, 'LABELS READY FOR USE', which marking would become invisible upon container **702** exceeding the precondition temperature and changing of the color of the thermochromic

Preferably, the thermochromic ink forming indicia **712** is of a reversible type, such that following a change of color thereof upon container **702** being cooled to at or below the precondition temperature, the thermochromic ink may revert to its previous color upon exceedance of the precondition temperature. Reversible thermochromic inks suitable for use with embodiments of the present invention are commercially available from a variety of manufacturers, including 'B and H Color Change' of Flintshire, UK and 'Chromatic Technologies, Inc.' of Colorado, USA.

Optionally, the indication of readiness for activation below the precondition temperature provided by thermochromic indicia **712**, may be augmented by an electronic mechanism indicating readiness for activation of multiplicity of quality labels **200**. By way of example, as shown here, an electronic circuit **720** may be appended to container **702** for the purpose of measuring temperature and/or time at temperature of container **702** and hence of multiplicity of labels **200** therein.

When multiplicity of labels **200** is ready for activation in accordance with a given formulation or decision table of temperature and/or time at temperature values as measured by electronic circuit **720**, such readiness for activation may be indicated. For example, a lock **730** located on container **702** and cooperatively coupled to electronic circuit **720** may be unlocked. Other indications of readiness for activation of quality labels **200**, as measured by electronic circuit **720**, may include the switching on or off of a light or the display of a digital message.

It is appreciated that thermochromic ink indicia **712** formed on container **702** are not limited to displaying a human-readable message and may alternatively comprise a machine-readable message, such as a barcode. Such a thermochromic barcode may change from a first readable state at a temperature below $T_{precondition}$ to a second readable state at a temperature above $T_{precondition.}$ Alternatively, such a thermochromic barcode may be invisible at temperatures above $T_{precondition}$ and may become visible upon container **702** being cooled to a temperature below $T_{precondition}$, or the reverse.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly claimed hereinbelow. Rather, the scope of the invention includes various combinations and subcombinations of the features described hereinabove as well as modifications and variations thereof as would occur to persons skilled in the art upon reading the forgoing description with reference to the drawings and which are not in the prior art.

The invention claimed is:

1. A system for providing an indication of exceedance of a temperature threshold, the system comprising:

at least one activatable quality label operative to provide a readable indication of exceedance of a temperature threshold following activation thereof at a temperature less than or equal to an activation temperature, said at least one activatable quality label including:

a readable indicator located on said quality label and operative, following activation of said quality label at or below said activation temperature, to readably indicate exceedance of said temperature threshold; and

an actuator element operative to activate said quality label; and

a container, containing said at least one activatable quality label therein, said container including indicia at least partially formed thereon by thermochromic ink, said thermochromic ink having a first visual appearance at temperatures less than or equal to said activation temperature and a second visual appearance at temperatures above said activation temperature, such that a visual appearance of said indicia on said container is indicative of whether said at least one quality label is at a temperature less than or equal to said activation temperature and hence may be activated.

2. A system according to claim **1**, wherein said readable indicator comprises a human-readable indicator.

3. A system quality label according to claim **1**, wherein said readable indicator comprises a machine-readable indicator.

4. A system according to claim **1**, wherein said indicia comprise human-readable indicia.

5. A system according to claim **1**, wherein said indicia comprise machine-readable indicia.

6. A system according to claim **1**, wherein said visual appearance of said thermochromic ink reversibly changes between said first visual appearance at temperatures less than or equal to said activation temperature and said second visual appearance at temperatures above said activation temperature.

7. A system quality label according to claim **1**, wherein said readable indicator comprises a barcoded indicator.

8. A system quality label according to claim **7**, wherein said barcoded indicator comprises a multiplicity of barcodes.

9. A system according to claim **1**, wherein said indicia comprise at least one barcode.

10. A system according to claim **9**, wherein said at least one barcode comprises a first barcode being machine-readable at temperatures less than or equal to said activation temperature and unreadable at temperatures greater than said activation temperature and a second barcode being unreadable at temperatures less than or equal to said activation temperature and machine-readable at temperatures greater than said activation temperature.

11. A system according to claim **1**, wherein said container also includes a temperature sensitive electronic circuit.

12. A system according to claim **11**, and also comprising a lock coupled to said temperature sensitive electronic circuit.

13. A system according to claim **11**, and also comprising a display coupled to said temperature sensitive electronic circuit.

14. A system according to claim **11**, and also comprising a light coupled to said temperature sensitive electronic circuit.

* * * * *